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Research Article

Visual pollution assessment in Mu Ko Chang National Park, Thailand: A landscape-based approach

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Abstract

This study presents a systematic, landscape-based assessment of visual pollution in Mu Ko Chang National Park, a popular nature-based tourism destination in Thailand. Eight types of visual disturbance including billboards, graffiti, garbage dumps, abandoned buildings, wastewater discharge points, improper use of public spaces, electric poles and wires and poorly maintained public utilities, were recorded across four different landscape zones: community areas and high, medium and low-density tourism areas. Fieldwork was conducted between November 2024 and January 2025, covering both high and low tourism seasons. Data were collected along 63 kilometres of designated survey routes using structured observation forms, GPS geotagging and triangulation to ensure spatial accuracy and methodological reliability. The findings indicate that electric poles and tangled overhead wiring were the most common form of visual degradation across all zones, contributing significantly to scenic fragmentation. Other disturbances, including unmanaged waste, excessive signage and graffiti, were concentrated in high-use areas with limited regulatory oversight, while low-density zones exhibited a high prevalence of abandoned infrastructure and billboard intrusion. ANOVA results confirmed statistically significant differences in visual pollution frequency amongst zones. The study reveals that visual pollution reflects not only aesthetic decline, but also broader challenges related to governance, land use and management disparities. It emphasises the need for spatially responsive and zone-specific strategies, integrating infrastructure regulation, visual landscape planning and community-based stewardship. By conceptualising visual pollution as a multidimensional conservation concern, the study contributes to a growing body of literature that illustrates for its integration into protected area monitoring and sustainable tourism planning frameworks.

Key words: Mu Ko Chang National Park, nature-based tourism, protected area , Thailand, tourism impact, visual pollution

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Introduction

Mu Ko Chang National Park, located in Trat Province in eastern Thailand, is one of the country's most ecologically and culturally significant protected areas. Encompassing over 40 islands, the Park features diverse ecosystems, includ-

ing evergreen rainforests, mangroves, coral reefs and pristine beaches, making it both a hub for biodiversity conservation and a popular nature-based tourism destination. Cultural assets, such as the royal monogram of King Rama V and commemorative landmarks, further enhance its appeal (Srisung and Chompunth 2020; DNP 2024). These natural and cultural attributes collectively position Ko Chang as a prominent destination for both domestic and international tourists. Activities such as trekking, snorkelling and beach recreation contribute to local livelihoods and the regional tourism economy, while community-based tourism initiatives increasingly attract visitors seeking authentic experiences linked to the natural environment.

Between 2020 and 2022, the Park experienced a sharp decline in tourism due to COVID-19-related closures, significantly affecting local communities and disrupting economic benefits within the Park. However, following the easing of restrictions, Mu Ko Chang experienced a rapid rebound, receiving over 1.5 million visitors and generating more than 15 billion Thai Baht in tourism revenue in 2024 (The Government Public Relations Department 2025). In the same year, it was ranked the world's second-best tropical holiday destination (The Government Public Relations Department 2024). While this recovery brings major socio-economic benefits, it also heightens environmental pressures, particularly in rapidly developing coastal zones. Development has been concentrated in high-density tourism areas, often overlooking low-density and local community zones, which now face unmanaged waste, visual degradation and inadequate infrastructure. Addressing these uneven impacts requires balancing conservation objectives, equitable infrastructure planning and sustainable tourism development across all zones of the Park.

Tourism development in natural protected areas increasingly emphasises sustainability, seeking to preserve ecological integrity and environmental quality while supporting economic growth and community participation. In Mu Ko Chang National Park, however, rapid and uncoordinated growth along the heavily visited western coastline has intensified land-use pressures, leading to habitat disturbance, infrastructure sprawl and marked landscape transformation (Srinonil et al. 2020). A key concern in this context is visual pollution, defined as the degradation of scenic quality caused by incongruent structures, excessive signage, unmanaged waste and poorly integrated infrastructure (Trišić et al. 2023). These disruptions reduce ecological and aesthetic value, diminish visitor satisfaction and threaten the long-term appeal of the destination (Hassan and Khalil 2024).

Despite increasing awareness of environmental impacts in protected areas, visual pollution remains a neglected topic in conservation and tourism research, particularly in natural settings. Most existing studies primarily focus on urban or cultural heritage environments, where visual degradation is often linked to billboards, graffiti and architectural incongruities (Clayton 2021; Bharadwaj et al. 2023; Gao et al. 2024; Gelan 2025). In cultural landscapes, it is associated with the loss of heritage value and aesthetic coherence (Liu et al. 2022; Zihao et al. 2022). However, visual disturbances in biodiversity-rich natural environments remain poorly documented, particularly in Southeast Asia.

In the context of protected area management, visual degradation may reflect broader governance challenges, including inadequate spatial planning, limited enforcement of environmental regulations and poor coordination amongst

tourism stakeholders (Su and Wall 2014; Widaningrum and Damanik 2018). These governance failures contribute to cumulative ecological degradation and a decline in ecosystem services, such as reduced water quality, loss of scenic and recreational value and diminished biodiversity, ultimately compromising the Park's capacity to support both conservation and sustainable tourism (Bell 2013). Moreover, poorly integrated infrastructure, such as commercial buildings, lodgings and signage, can erode landscape character, commodify cultural identity and disrupt ecological connectivity (Gössling and Peeters 2015; Morales Yago et al. 2024).

Natural landscapes are not simply background settings for recreation. They are central to destination identity, visitor experience and ecological resilience. Few studies have examined how visual pollution affects the quality of protected areas or the sustainability of tourism in such contexts. This lack of empirical research limits effective landscape planning and hinders the development of guidelines for visually compatible infrastructure in protected areas. To address this gap, this study examines the spatial distribution and typologies of visual pollution in Mu Ko Chang National Park. It classifies anthropogenic disturbances affecting scenic quality and analyses their prevalence across zones with varying levels of tourism development. By linking patterns of visual pollution to tourism intensity, the study aims to provide information for landscape-sensitive management practices and conservation-focused spatial planning. The findings offer practical guidance for improving the aesthetic and ecological integrity of protected areas under growing tourism pressure.

Literature review

Visual pollution

Visual pollution refers to the presence of intrusive or incongruent elements in the environment that disrupt the visual harmony, coherence and aesthetic value of a landscape (Yiljika and Danna 2014). It is commonly associated with human-made features, such as signage, infrastructure and waste that contrast with natural surroundings in terms of shape, colour, scale or spatial arrangement (Elleithi et al. 2022). In protected areas, visual pollution represents a form of landscape degradation that threatens not only scenic quality, but also ecological integrity, conservation value and visitor experience. These intrusions obscure or alter natural beauty and often reflect broader environmental pressures, such as habitat fragmentation, unregulated development or inadequate land-use planning. As a result, visual pollution can disrupt ecological processes, degrade habitat quality and interfere with species behaviour, while also reducing visitor satisfaction and diminishing cultural appreciation of nature (Piquard and Swenarton 2011; Pettebone et al. 2011; Dostál et al. 2024; Huepa Briñez and Florez-Yepes 2025).

Although perceptions of visual pollution are inherently subjective, studies across diverse contexts consistently show that elements incongruent with natural landscapes diminish perceived scenic value and ecological integrity in protected areas (Helldin 2019; Wójcicki et al. 2023). Understanding the nature and implications of visual pollution is, therefore, crucial for conservation management, particularly for spatial planning and policy aimed at maintaining ecological and visual qualities under increasing tourism pressure.

Despite extensive work on visual pollution in urban and suburban settings, it remains under-researched in natural protected areas, where visual quality is central to conservation objectives (Helldin 2019; Wójcicki et al. 2023). In these landscapes, visual intrusions may signal broader problems, such as land-use change, tourism overdevelopment or governance shortcomings, with implications for both ecological functions and human–nature relationships (Piquard and Swenarton 2011; Pettebone et al. 2011; Dostál et al. 2024). From a landscape perception perspective, visual pollution affects key components of aesthetic experience, particularly legibility, coherence and naturalness, which are closely related to visitor preferences and place attachment (Kaplan and Kaplan 1989; Cheng et al. 2003; Gelan 2025). A degraded visual environment can erode public support for conservation, discourage pro-environmental behaviour and reduce repeat visitation, making understanding of visual impacts fundamental to effective conservation planning, visitor management and long-term landscape conservation.

Visual pollution in natural areas consists of intrusive elements that diminish scenic and aesthetic quality (Hassan and Khalil 2024). It typically includes excessive signage and advertising displays, where commercial boards, banners and directional signs clutter views and disrupt the natural harmony. Such intrusions diminish the sense of place and reduce visitor satisfaction in protected areas (Marion and Reid 2007; Gelan 2025). Non-harmonious built structures, such as oversized or poorly integrated buildings, roads and parking areas, can significantly alter the character of natural landscapes. When these structures conflict with their surroundings, they disrupt visual coherence and reduce overall scenic quality (Saghir 2019). Utilities and technical installations, including overhead lines, towers, pipelines and neglected facilities, fragment the landscape and signal poor maintenance. Additionally, poorly maintained structures, such as rusted signposts or deteriorating facilities, indicate neglect and contribute to the deterioration of visual quality (Qaseem and Khayat 2024). Litter and waste accumulation, such as garbage dumps, overflowing bins and scattered plastic, reduces both ecological and visual quality and reflects inadequate site management (Nawaz and Wakil 2022). Landscape degradation, evident in deforestation, bare soil, eroded trails and unstable slopes from unsustainable land use, undermines scenic quality and biodiversity and negatively influence visitor perceptions of environmental health and site value (Jayathilake et al. 2021). Finally, visitor-induced crowding, seen in dense clusters of people, vehicles and temporary structures, disrupts naturalness and tranquillity and can significantly reduce perceived scenic quality, especially in destinations where solitude or pristine conditions are central to the experience (Liang et al. 2021). Managing this form of visual disruption is essential for sustaining landscape integrity and promoting responsible tourism.

These visual disturbances are not merely physical intrusions; they also signal broader conservation challenges, such as fragmented governance, limited financial resources and inadequate spatial planning. Despite their ecological and experiential significance, visual pollution indicators remain largely absent from most protected area monitoring frameworks, including the Limits of Acceptable Change (LAC) and the Visitor Experience and Resource Protection (VERP) systems (Manning et al. 2009). This gap highlights the urgent need for systematic assessment and spatial mapping of visual pollution as a foundation for evidence-based conservation planning.

Understanding the characteristics and distribution patterns of visual pollution in natural protected areas is essential for several interconnected reasons. First, it enables the identification of high-impact zones requiring ecological restoration. Second, it provides information for zoning and infrastructure decisions aimed at minimising further visual disruption. Third, managing visual pollution helps maintain scenic quality and enhances overall visitor experience. Finally, it supports public communication and contributes to the development of policies for long-term conservation. Addressing visual pollution through a spatial, landscape-based approach is, therefore, critical to preserving both the ecological integrity and visual character of protected areas, particularly under the pressures of expanding tourism and infrastructure development.

Landscape management strategies for tourism-orientated protected areas

Protected areas are clearly defined geographical spaces that are legally or effectively managed to ensure the long-term conservation of biodiversity, ecosystem processes and associated natural and cultural values, including the ecosystem services they provide (International Union for Conservation of Nature 2020). These areas encompass various categories, such as wildlife sanctuaries, national parks, non-hunting areas and biosphere reserves, all established to protect or restore ecological integrity. Effective protected area management requires balancing conservation objectives with sustainable human use, particularly where socio-economic interests overlap with ecological concerns. In this manner, protected areas play a critical role in preserving biodiversity, maintaining ecosystem services and conserving landscapes of ecological, cultural and aesthetic importance. To minimise human pressures, these areas are typically subject to regulated use and restricted development (Zbierska 2022).

In protected areas where tourism is a significant land use, landscape management must be approached as a proactive, interdisciplinary process that supports conservation, education and community participation. This is especially critical in regions experiencing rapid tourism growth and land-use change, such as Southeast Asia, where protected areas like Khao Yai National Park (Thailand), Bromo Tengger Semeru National Park (Indonesia) and Kinabalu Park (Malaysia) face challenges in balancing ecosystem protection with rising tourist demands (Cochrane 2003; Goh and Yusoff 2010; DNP 2024). In Thailand, for example, tourism within national parks contributes substantially to local economies, but has also resulted in overcrowding, unmanaged waste and visual degradation in popular areas, such as Mu Ko Chang, Doi Inthanon and Erawan National Park (Kaewnuch 2017). These examples emphasise the need for integrated management strategies that safeguard ecological and visual integrity while supporting sustainable visitation.

Effective management must integrate ecological principles with an understanding of local socio-cultural dynamics to protect both the ecological integrity and visual quality of protected landscapes (Bulcão et al. 2004; Bhammar et al. 2021; Mileusnić Škrtić et al. 2024). International frameworks, such as the IUCN Green List of Protected and Conserved Areas, promote good governance, sustainable design and effective management as core criteria for achieving conservation outcomes (IUCN and World Commission on Protected

Areas 2017). Similarly, the Global Sustainable Tourism Council (GSTC) provides destination-level standards for planning, visitor management and stakeholder involvement, emphasising visual harmony and landscape protection (The Global Sustainable Tourism Council 2019). Integrating local practices within these frameworks can enhance both ecological and experiential quality in protected area tourism.

Based on previous research and practice, five key components have been identified to support landscape management in tourism-orientated protected areas. These components provide a practical and comprehensive framework for integrating conservation goals with tourism and community benefits:

1) Environmental Conservation .emphasises the protection of biodiversity, ecosystem functions and the sustainable use of natural resources. Management approaches include ecological monitoring, enforcement of habitat protection regulations and ecological restoration using native species. Infrastructure development should follow low-impact design principles and be subject to visual and environmental impact assessments. Maintaining vegetation buffers and limiting vehicular access — through walking trails or electric shuttle systems — can further reduce ecological disturbance and landscape fragmentation (Graziano et al. 2022).
2) Visitor Management focuses on maintaining both environmental quality and visitor experience. Effective strategies include defining and monitoring site-carrying capacity, implementing spatial zoning (e.g. core conservation zones, recreational areas, intensive use zone) and constructing eco-friendly infrastructure, such as boardwalks or composting toilets. Interpretive signage, natural screening and technologies, like reservation systems or visitor flow monitoring, can help disperse visitor concentrations and reduce visual and physical impacts in fragile areas (Turton 2005).
3) Cultural Heritage Preservation focuses on the protection of both tangible and intangible heritage values, including sacred sites, traditional land-use practices and historical landmarks integrated with natural landscapes. Engaging local custodians, community stakeholders and experts in heritage interpretation and protection is essential. Tourism infrastructure should incorporate local materials and culturally reflective design, while interpretive programmes can enhance awareness of cultural narratives. Limiting commercial activity near sensitive sites helps preserve cultural authenticity and scenic harmony (Wasela 2023).
4) Community Involvement is crucial for inclusive, place-based landscape management. Participatory planning, co-management models and benefit-sharing mechanisms ensure that communities have a responsible and share in the benefits of tourism and conservation outcomes. Local residents can contribute to visual monitoring, landscape maintenance and eco-landscaping, while also providing interpretive services and small-scale tourism enterprises. Supporting local crafts and sustainable livelihoods helps reinforce cultural identity and supports long-term stewardship (Gopal 2023).
5) Sustainable Tourism Practices support the long-term condition of both ecosystems and communities. These include promoting ecotourism,

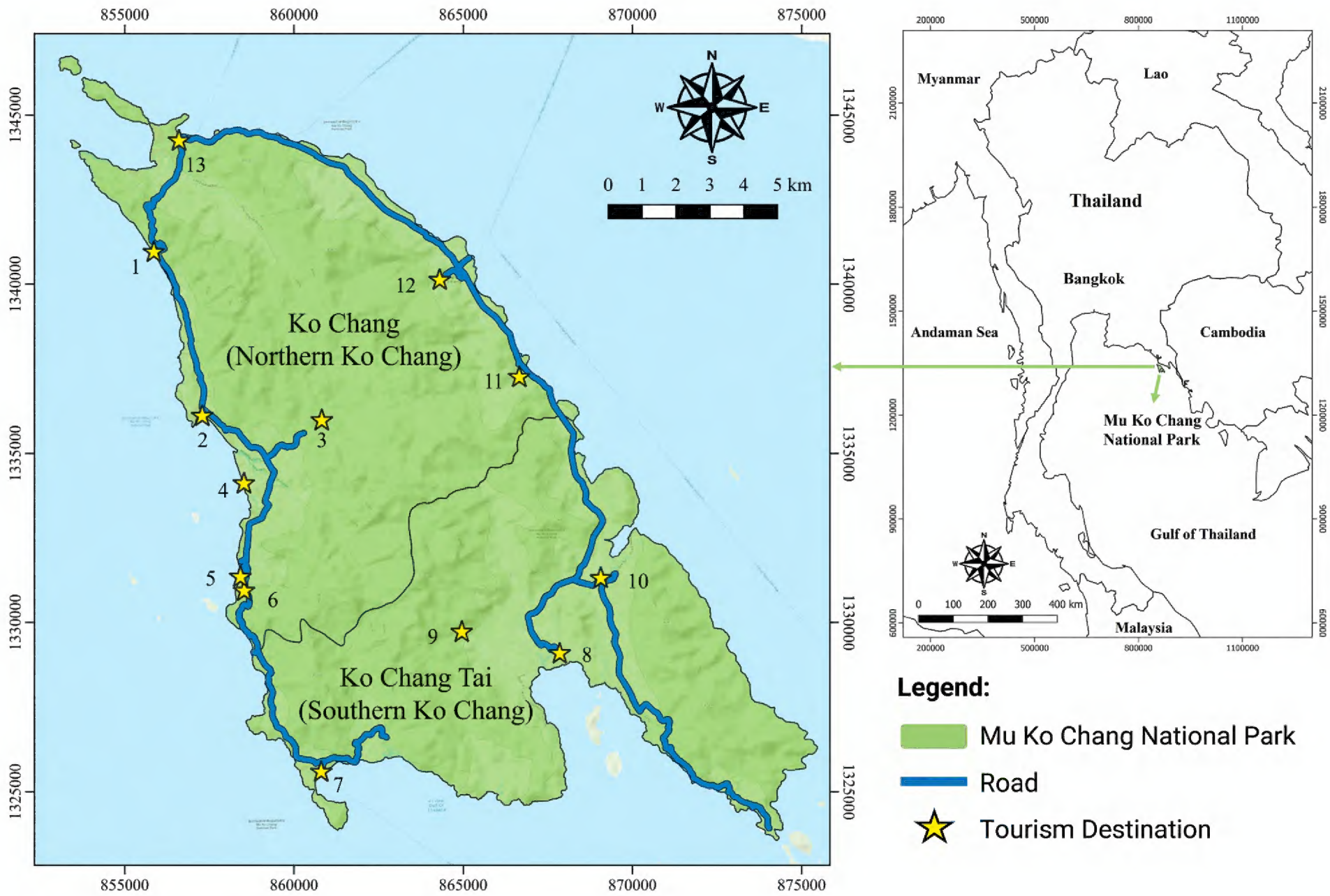
adopting green technologies (e.g. solar power, water-saving systems) and implementing waste reduction strategies using well-integrated collection points. Tourism infrastructure should be designed to integrate seamlessly with the natural landscape, using harmonious colour schemes and unobtrusive, minimalist architectural elements. Visitor education programmes can enhance environmental ethics and encourage responsible behaviour (Adi Pratama et al. 2024). Sustainability certification systems can further guide tourism operators towards compliance with conservation objectives (Bozdaglar 2023).

Together, these five components and their associated practices provide a holistic approach to landscape management in tourism-orientated protected areas. When effectively implemented, they ensure that tourism contributes to ecological preservation, community well-being and cultural continuity, while enhancing environmental awareness and building long-term support for protected area conservation (Leung et al. 2018; Blanco-Cerradelo et al. 2022; Stojanović et al. 2022; Kaur et al. 2025).

Materials and methods

Study area

This study focuses on Mu Ko Chang National Park in Trat Province, Thailand, as the primary study area. The research covers two subdistricts, including Ko Chang Subdistrict (northern Ko Chang) and Ko Chang Tai Subdistrict (southern Ko Chang), which differ in their patterns of development and land-use contexts, influencing the composition and visual character of the landscape within the National Park (Inocente et al. 2023). Northern Ko Chang serves as the island's main tourism area and is the location of the primary ferry terminal connecting the island to the mainland (Laem Ngop District, Trat Province). This area is characterised by high concentrations of tourism infrastructure, including hotels, resorts, shops, restaurants and various visitor amenities (Department of National Parks, Wildlife and Plant Conservation [DNP] 2024). It is also the location of the island's most popular attractions, such as White Sand Beach, Khlong Plu Waterfall, Kai Bae Viewpoint and Tharn Mayom Waterfall. During the high season, this subdistrict experiences a significant influx of visitors, resulting in noticeable landscape changes, driven by tourism-related economic activities (DNP 2024). By contrast, Ko Chang Tai Subdistrict has retained more of its natural environmental character, with relatively lower levels of tourism development. This area includes several local communities, such as Bang Bao Village, Salak Phet Village and Salak Khok Village, which maintain traditional lifestyles. These are prominent fishing communities whose livelihoods remain closely connected to marine resources. Tourism in this subdistrict is orientated more towards ecotourism and cultural experiences, with homestay accommodations being the predominant lodging type. The boundaries of these two subdistricts are illustrated in Fig. 1, which serves as a basis for data collection and analysis of visual pollution impacts within the context of natural protected area.



Tourism Destination:

1. White Sand beach
2. Chai Chet beach
3. Khlong Phlu Waterfall
4. Klong Prao Beach
5. Kai Bae Beach
6. Kai Bae Viewpoint
7. Bang Bao Village
8. Salak Phet Village
9. Khiri Phet Waterfall
10. Salak Khok Village
11. Tharn Mayom Waterfall
12. Khlong Nonsi Waterfall
13. Chao Por Ko Chang Shrine

Figure 1. Mu Ko Chang National Park, Trat Province, Thailand and key tourism destinations within the Park.

Conceptual framework

This research consists of two main parts:

Part 1 of this study analyses the types of visual pollution occurring within Mu Ko Chang National Park. Visual pollution was classified into eight categories, based on the typology proposed by Wakil et al. (2019) including: 1) billboards; 2) graffiti; 3) garbage dumps; 4) abandoned buildings; 5) wastewater discharge points; 6) improper use of public spaces; 7) electric poles and wires and 8) poorly maintained public utilities. This classification aims to identify environmental features that contribute to visual pollution and to facilitate analysis within the specific context of tourism in natural protected area.

The study in Part 2 focuses on comparing the occurrences of various types of visual pollution across the four designated landscape zones within Mu Ko Chang National Park (Fig. 2). These zones include: 1) high-density tourism zone (13 km), comprising popular beach areas and major attractions with extensive infrastructure and heavy visitor flow; 2) medium-density tourism zone (8 km), which includes areas with moderate visitor activity and mixed land use; 3) low-density tourism zone (5 km), representing remote or less-developed areas

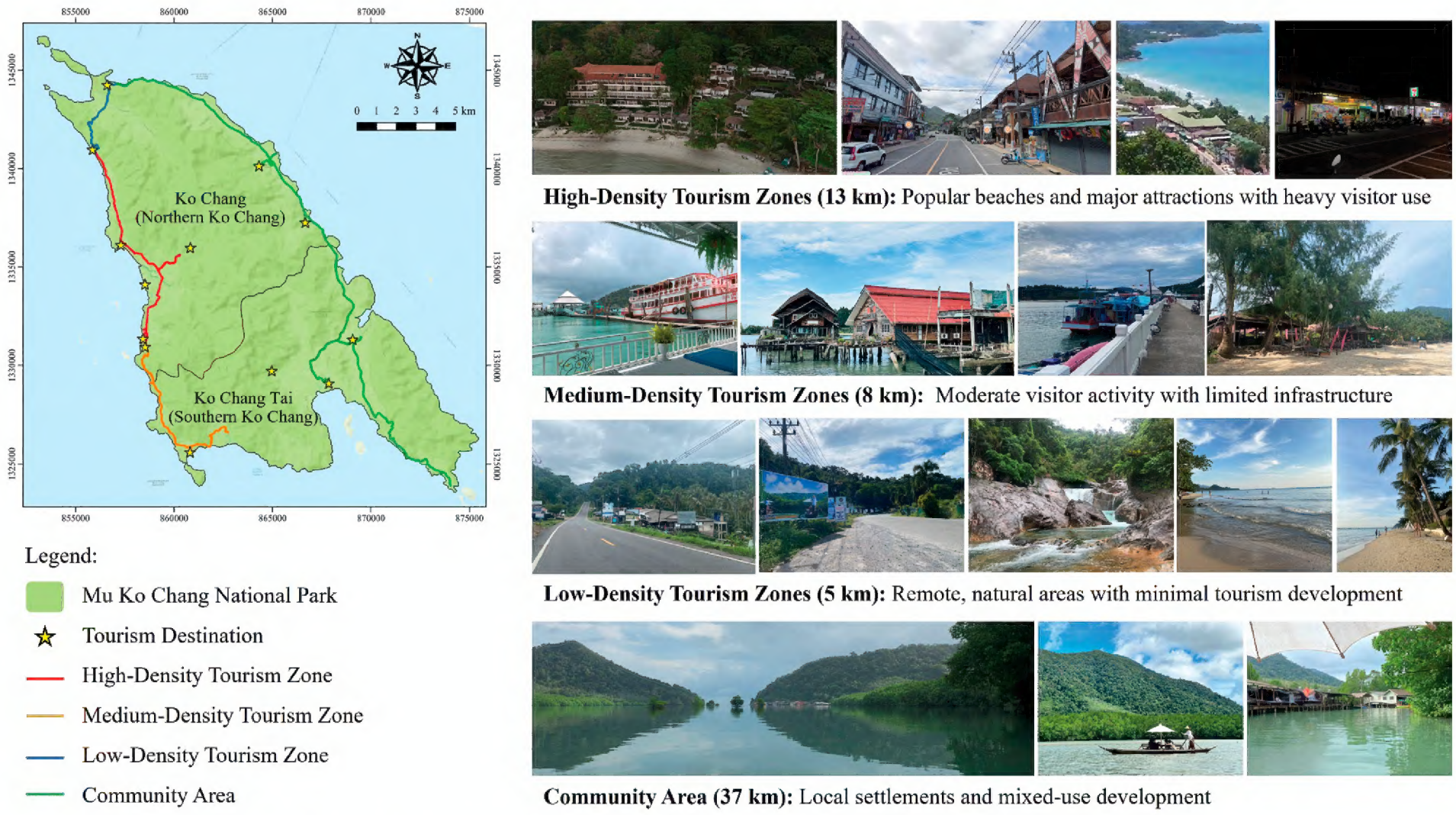


Figure 2. Landscape zoning in Mu Ko Chang National Park, classified by tourism density levels.

with minimal tourist presence and infrastructure, often retaining more natural and undisturbed characteristics; and 4) community area (37 km) dominated by local settlements and mixed-use development, including fishing villages and residential zones (Fig. 2).

Data collection

Data collection for this study was conducted through a field survey using the route survey method in combination with structured observation forms. Fieldwork was carried out between November 2024 and January 2025, covering both high and low tourism periods to account for seasonal variation in visitor activity. The survey routes were selected, based on the Park's primary transportation network, including roads and trails commonly used by tourists, to ensure coverage of areas most likely to exhibit visual pollution. A total of eight predefined categories of visual pollution were assessed, which were developed through a synthesis of previous research and adapted to the specific context of Mu Ko Chang National Park:

1. Billboards: Large advertising signs placed along roadsides or in scenic areas that often disrupt natural views and the visual harmony of the landscape.
2. Graffiti: Unauthorised writing, drawings or symbols applied to public surfaces, degrading the visual quality and perceived cleanliness of an area.
3. Garbage dumps: Accumulations of litter or improperly disposed waste, including overflowing bins or informal dumping sites, that negatively affect the appearance and hygiene of the landscape.
4. Abandoned buildings: Unused or deteriorating structures left in disrepair, contributing to a sense of neglect and visual degradation in the environment.

5. Wastewater discharge points: Visible outlets where untreated or partially treated wastewater is released into natural areas, often accompanied by discoloration, odour or damage to the surrounding scenery.
6. Improper use of public spaces: Misuse or cluttering of shared areas (e.g. roadside stalls, unauthorised parking or storage) that disrupt the intended function and visual order of the landscape.
7. Electric poles and wires: Overhead utility infrastructure that creates visual clutter, especially when densely concentrated or placed at scenic viewpoints.
8. Poorly maintained public utilities: Infrastructure such as signage, benches, lighting or drainage systems that are damaged, rusted or poorly kept, diminishing the aesthetic appeal of public areas.

Structured observation forms were used to ensure systematic and consistent data collection across all routes. These forms were designed around the eight visual pollution categories and refined through expert input and contextual adaptation. Prior to fieldwork, researchers were trained to standardise their ability to identify, classify and record visual pollution accurately. The training included the use of photo-based examples, trial assessments and calibration exercises to align observers' interpretations and minimise variability in field judgements. Additionally, to further reduce observer bias, inter-observer agreement was established through joint assessments at selected locations during the initial phase of data collection. A triangulation approach was employed to enhance data reliability, combining field observations, photographic documentation and GPS-based location data. Each identified instance of visual pollution was geotagged and categorised on-site, resulting in a spatially explicit dataset suitable for subsequent spatial and thematic analysis.

Data analysis

The analysis was conducted in two parts. First, descriptive statistics were used to examine the characteristics and frequency of the eight types of visual pollution observed throughout the Park. Second, a comparative analysis was performed to assess differences in visual pollution across four designated zones — high-density tourism zone, medium-density tourism zone, low-density tourism zone and community area — using analysis of variance (ANOVA).

Results

Spatial patterns and frequency of visual pollution in Mu Ko Chang National Park

Based on field survey results, eight types of visual pollution were recorded across Mu Ko Chang National Park (Fig. 3). The most frequently observed type of visual pollution was electric poles and wires, with an average of 18.43 occurrences per kilometre, followed by garbage dumps (1.21 occurrences/km) and billboards (1.14 occurrences/km). When the data were disaggregated by zone, electric poles and wires emerged as the most prevalent visual pollutant in all areas. The results demonstrated that, in the high-density tourism zone, the most frequently encountered pollutants were electric poles and wires, garbage

Figure 3. Types of Visual Pollution Observed in Mu Ko Chang National Park. Note. Sample illustrations of visual pollution types observed in Mu Ko Chang National Park: **a.** Billboards; **b.** Graffiti; **c.** Garbage dumps; **d.** Abandoned buildings; **e.** Wastewater discharge points; **f.** Improper use of public spaces; **g.** Electric poles and wires; **h.** Poorly maintained public utilities.

dumps and graffiti. For the medium-density tourism zone, the most common types were electric poles and wires, improper use of public spaces and billboards. In the low-density tourism zone, electric poles and wires, billboards and garbage dumps were identified as the top three types. Finally, in the community zone, the top three visual pollution types were electric poles and wires, graffiti and billboards (Fig. 4 and Table 1). A detailed examination of each type of visual pollution and its frequency of occurrence across the different four zones is presented as follows.

Billboards: The results from field survey indicated that most billboards observed within Mu Ko Chang National Park were designed to be highly conspicuous, often featuring large dimensions, vivid colours and placement in high-visibility areas, such as roadsides and pedestrian zones. In addition to standard billboard formats, such as banners, posters and LED signs, some installations were found to negatively impact natural elements, including instances where signs were nailed directly on to trees, causing ecological harm. When analysing billboard frequency per kilometre, the low-density tourism zone exhibited the highest occurrence (7.2/km), followed by the medium-density (1.25/km) and high-density tourism zones (1.23/km). In contrast, the community zone had the lowest density (0.27/km). These results indicate that billboard proliferation is particularly pronounced in low-density tourism areas, likely due to weaker regulatory oversight or enforcement. This trend reflects a tendency amongst local businesses to use billboard advertising as a primary tool to attract visitors, es-

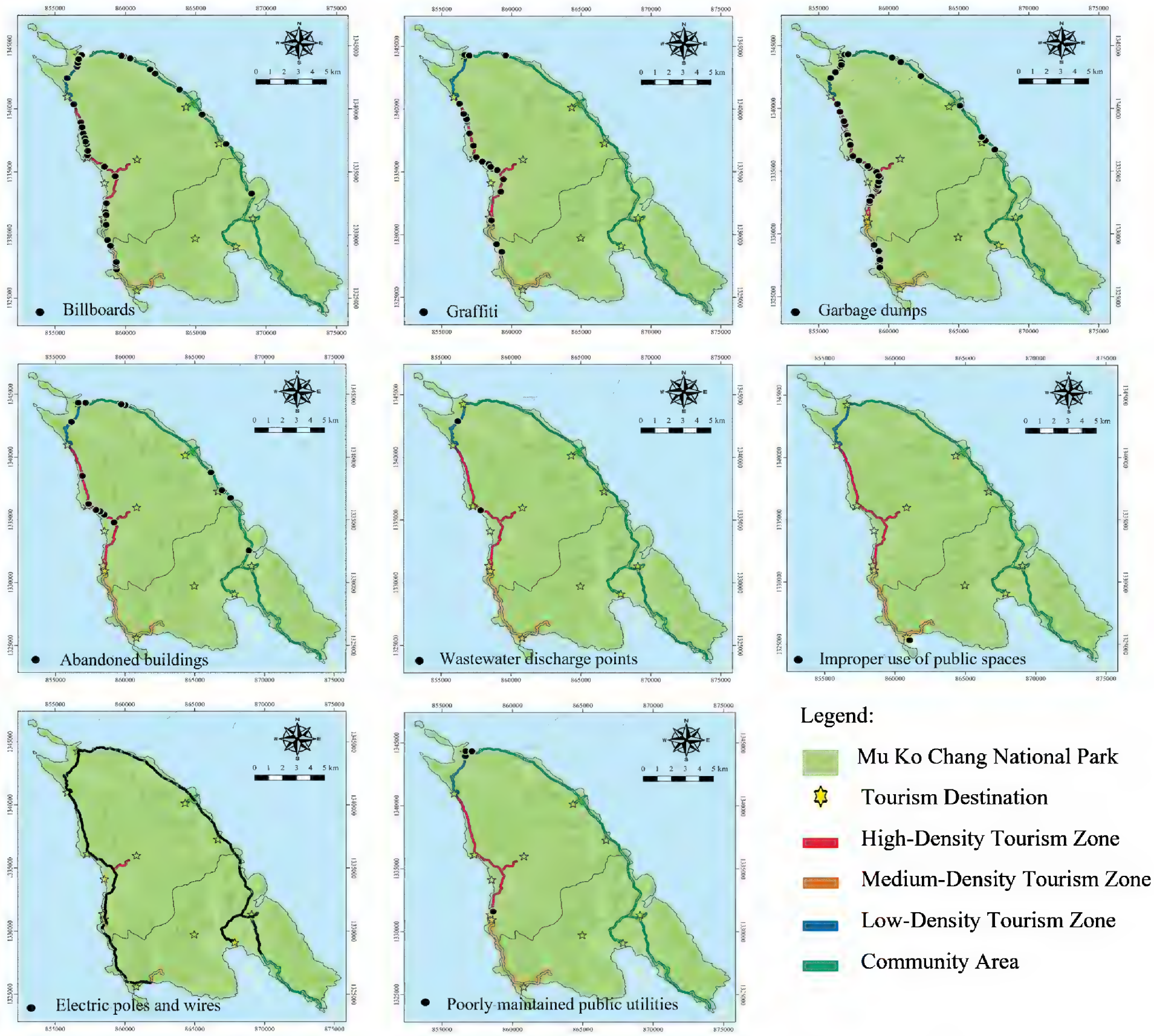


Figure 4. Spatial distribution of visual pollution occurrences in Mu Ko Chang National Park. Note. The points illustrate the types of visual pollution observed in Mu Ko Chang National Park, including: **a.** Billboards; **b.** Graffiti; **c.** Garbage dumps; **d.** Abandoned buildings; **e.** Wastewater discharge points; **f.** Improper use of public spaces; **g.** Electric poles and wires; **h.** Poorly maintained public utilities.

pecially in areas with lower tourist traffic. Conversely, in higher-traffic zones, the number of billboards is lower, potentially due to stricter landscape regulations or visual management policies in place to preserve the aesthetic quality of key tourism sites.

Graffiti: Graffiti in Mu Ko Chang National Park was primarily found in public spaces and appeared in various forms, including both artistic expressions and textual markings. When examining the frequency of graffiti per kilometre, the results revealed that it was most frequently observed in the high-density tourism zone (1.69 occurrences/km), while much lower rates were recorded in other zones. This concentration may be attributed to increased visitor activity and insufficient monitoring in high-tourism areas. The findings suggest that graffiti tend to appear in areas with high visitor flow, particularly around popular attractions and transit points. This may reflect an intent by graffiti artists to gain visibility in prominent locations or it could result from deviant tourist behaviour, such

Table 1. Analysis of variance (ANOVA) of visual pollution types across tourism zones in Mu Ko Chang National Park.

Types of visual pollution	Number of Occurrences		Area				F	*p*
			High-Density Tourism Area (13 km)	Medium-Density Tourism Area (8 km)	Low-Density Tourism Area (5 km)	Community Zone (37 km)		
Billboards	Total (63 km)	72	16	10	36	10	8.468	0.000
	occurrences/km		1.23	1.25	7.2	0.27		
	SD		1.42	1.28	10.43	0.77		
Graffiti	Total (63 km)	38	22	2	2	12	9.897	0.000
	occurrences/km		1.69	0.25	0.40	0.32		
	SD		1.55	0.71	0.55	0.66		
Garbage dumps	Total (63 km)	79	34	5	7	7	21.405	0.000
	occurrences/km		2.61	0.62	1.4	0.18		
	SD		1.76	0.92	1.14	0.40		
Abandoned buildings	Total (63 km)	18	6	-	4	8	2.254	0.091
	occurrences/km		0.46	-	0.8	0.21		
	SD		0.78	-	0.45	0.63		
Wastewater discharge points	Total (63 km)	2	1	-	1	-	2.453	0.072
	occurrences/km		0.07	-	0.20	-		
	SD		0.35		0.45			
Improper use of public spaces	Total (63 km)	19	-	19	-	-	2.453	0.072
	occurrences/km		-	2.37	-	-		
	SD			6.72				
Electric poles and wires	Total (63 km)	1,161	369	186	144	462	21.340	0.000
	occurrences/km		28	23.25	28.80	12.49		
	SD		7.32	9.25	2.28	7.07		
Poorly maintained public utilities	Total (63 km)	4	1	-	3	-	7.741	0.000
	occurrences/km		0.07	-	0.6	-		
	SD		0.28		0.89			

as leaving markings or messages in crowded public spaces. In contrast, more remote or less-developed zones showed significantly fewer instances — likely due to reduced tourist presence and better preservation of the natural landscape.

Garbage dump: Garbage dumps represent a significant issue affecting both the environment and the visual quality of tourist destinations. When examining the frequency of garbage dumps per kilometre, the study found the highest concentration in the high-density tourism zone (2.61 occurrences/km), which was substantially higher than in other zones. In contrast, the local community zone recorded the lowest rate at only 0.18 occurrences/km. These results highlight a clear correlation between tourist density and the accumulation of unmanaged waste. This finding underscores the severity of solid waste problems in tourism areas, particularly in zones with high visitor traffic and intensive land use. The presence of garbage not only disrupts the visual appeal of the landscape, but also signals inadequate waste management practices, which may detract from visitor satisfaction and undermine the area's natural and aesthetic values.

Abandoned buildings: An examination of the frequency of abandoned buildings per kilometre, the study showed that this issue was most prominent in the low-density tourism zone (0.80 occurrences/km), followed by the high-density tourism zone (0.46 occurrences/km) and the community area (0.21 occurrenc-

es/km). These findings indicate that abandoned buildings are a widespread issue within Mu Ko Chang National Park, particularly in low-density tourism areas where land use appears to be poorly planned or underutilised. The high frequency of abandoned structures in these zones may reflect several underlying causes, including stalled development projects, seasonal business closures or insufficient investment in sustainable tourism infrastructure. In particular, the lingering effects of the COVID-19 pandemic have likely exacerbated the situation, as many tourism-related businesses were forced to shut down due to prolonged travel restrictions and reduced visitor numbers. As a result, several facilities remain unused or neglected, contributing to visual degradation and undermining the area's appeal to future visitors. This not only diminishes the scenic quality of the landscape, but also signals inefficient land management and lost economic potential for the region.

Wastewater discharge points: During the examination of the frequency of wastewater discharge points per kilometre, the study found that this issue was most prevalent in the low-density tourism zone (0.20 occurrences/km), followed by the high-density tourism zone (0.07 occurrences/km). No wastewater discharge points were recorded in the community or medium-density tourism zones. Although the overall number of occurrences was relatively low, the presence of wastewater discharge points remains a notable concern, especially in the low-density tourism areas where its frequency was highest. These discharge points significantly impact the scenic and environmental quality of tourist destinations. In natural settings, visible signs of wastewater not only degrade aesthetic values, but also pose broader environmental risks, such as water pollution and ecosystem disruption. The findings suggest a need for improved wastewater management infrastructure and stricter monitoring, particularly in less-developed areas where management and treatment systems may be lacking.

Improper use of public spaces: In Mu Ko Chang National Park, improper use of public spaces was observed in various forms, including unregulated boat docking, roadside parking, unauthorised street stalls and other obstructions in shared public areas. When examining the frequency of these occurrences per kilometre, the study found that such issues were recorded only in the medium-density tourism zone (2.37 occurrences/km), with no cases observed in other zones. Most incidents involved boat docking in areas not designated for such use. This concentration may reflect the mixed development status of the medium-density zone, where regulation and infrastructure may not yet be fully established. The improper use of public spaces, particularly boat docking outside designated zones, can negatively affect the visual appeal of the environment and diminish the overall aesthetic quality of the landscape. Such practices can undermine the attractiveness of the destination, disrupt the natural scenery and signal a lack of effective spatial planning and enforcement.

Electric poles and wires: Electric poles and wires were amongst the most frequently observed forms of visual pollution in Mu Ko Chang National Park. These commonly appeared as clusters of utility poles along roadsides and near residential areas, with tangled power lines and low-hanging communication cables contributing to a visually disordered streetscape. When examining the frequency of occurrences per kilometre, this issue emerged as the most widespread visual pollutant across all zones, particularly in the low-density tourism

zone (28.80/km) and the high-density tourism zone (28.38/km), while the community zone recorded the lowest density (12.49/km). These findings suggest a systemic lack of visual impact mitigation and infrastructure planning in both newly-developing and already developed tourism corridors. The prevalence of overhead utility infrastructure not only disrupts scenic views and degrades the aesthetic quality of the landscape, but also reflects limited efforts to implement visually sensitive solutions, such as underground cabling or organised utility corridors, which are commonly adopted in tourism-sensitive environments. This issue also points to an institutional gap: local governments and utility service providers often prioritise functionality and cost-efficiency over visual harmony in protected or scenic areas. Despite the area's designation as a National Park, there appears to be limited enforcement or planning to align infrastructure with conservation or tourism development goals. The lack of coordination amongst tourism planners, local municipalities and energy or communication providers has resulted in the unchecked proliferation of electrical infrastructure. In addition to visual disruption, these installations pose safety risks to both tourists and residents. Without strategic planning or regulations to address the visual and physical hazards posed by utility infrastructure, the long-term sustainability and appeal of Mu Ko Chang as a nature-based destination may be undermined.

Poorly maintained public utilities: This type of visual pollution typically manifested in damaged road surfaces, abandoned public telephone booths and other neglected infrastructure. Field observations identified such instances primarily in the low- and high-tourism zones, while no cases were recorded in the medium-density tourism and community zones. When examining the frequency per kilometre, these occurrences were relatively rare, but showed notable variation, with the low-density tourism area reporting the highest rate (0.6 occurrences/km). This pattern suggests a level of neglect in less-visited areas, potentially due to limited maintenance efforts by local authorities or a lack of investment from tourism-related businesses. Although the overall frequency was low, poorly maintained utilities can still negatively affect the scenic quality and perceived attractiveness of tourist destinations. Their presence may indicate insufficient infrastructure planning and reduced commitment to upholding visitor experience standards in less prioritised zones.

Statistical analysis of visual pollution occurrence across landscape zones

To further investigate spatial differences in visual pollution, a one-way analysis of variance (ANOVA) was conducted to assess whether the frequency of visual pollution types varied significantly across the four designated landscape zones within Mu Ko Chang National Park: community areas, high-density tourism zones, medium-density tourism zones and low-density tourism zones. The analysis revealed statistically significant differences in the frequency of several visual pollution types between zones. Notably, significant variations were observed for billboards ($F = 8.468$, $p < 0.001$), graffiti ($F = 9.897$, $p < 0.001$), garbage dumps ($F = 21.405$, $p < 0.001$), electric poles and wires ($F = 21.340$, $p < 0.001$) and poorly maintained public utilities ($F = 7.741$, $p < 0.001$). These results suggest that the occurrence of these visual pollution types is not evenly

distributed across zones and may be influenced by levels of tourism development, land use or infrastructure density.

In contrast, no statistically significant differences were found in the frequency of wastewater discharge points, abandoned buildings and improper use of public spaces ($p > 0.05$), indicating that these types of visual pollution may occur more uniformly across different zones or be less influenced by zoning characteristics. A summary of these results is presented in Table 1.

Discussion

This study reveals the spatial differentiation of visual pollution across Mu Ko Chang National Park, reflecting not only varied aesthetic disruptions, but also deeper structural challenges in protected area governance. The findings illustrate that visual pollution occurring in the Park is not merely an aesthetic issue, but reflects deeper structural challenges, including uneven infrastructure investment, inconsistent enforcement and gaps in governance across different management zones. Similar patterns have been reported in cultural landscapes and urban tourism destinations, where advertising clutter, unregulated construction and infrastructure concentration in core areas generate visual pollution; however, in a protected-area context, these impacts are compounded by their direct implications for ecological integrity and nature-based visitor experience (Liu et al. 2022; Zihao et al. 2022; Gelan 2025).

The dominance of electric poles and overhead wiring emerged as the most persistent and visually disruptive form of pollution across all landscape zones in Mu Ko Chang National Park. Their presence, regardless of tourism intensity or land-use type, highlights a critical systemic issue of uncoordinated infrastructure development within a conservation context. Similar patterns have been observed in destinations such as Addis Ababa, Ethiopia and in several protected areas experiencing rapid post-COVID-19 tourism recovery, where development has progressed faster than the implementation of visual and environmental protection (Bhammar et al. 2021; Gelan 2025). In Mu Ko Chang, utility structures frequently lack standardised design, are inadequately maintained and disrupt both the scenic quality and ecological integrity of sensitive landscapes. The higher concentration of upgraded or concealed wiring systems in high-tourism zones further indicates a disproportionate allocation of resources towards revenue-generating areas. This raises concerns about spatial equity in protected area governance, particularly the neglect of low-density and community zones in efforts to maintain visual and ecological integrity. Addressing this imbalance requires the establishment of park-wide visual infrastructure standards that prioritise conservation values over economic gain, ensuring consistent aesthetic and environmental quality across all zones.

Waste accumulation and excessive signage in both high- and low-tourism zones of Mu Ko Chang National Park reflect significant shortcomings in institutional management and spatial planning. The high frequency of garbage dumps and billboards indicates not only inadequate waste infrastructure and weak enforcement of advertising regulations, but also a broader failure to align land-use planning with conservation objectives. In high-tourism areas, these issues are often driven by high visitor demand and limited maintenance capacity. Conversely, in low-tourism zones, the absence of effective enforcement

mechanisms has enabled the unchecked spread of unauthorised signage and improper waste disposal. These trends reveal a disconnection between land-use demands and the Park's environmental carrying capacity, underscoring the need for spatially responsive and zone-sensitive management. These findings align with international studies from urban-fringe protected areas, such as those reviewed by Bhammar et al. (2021), Hassan and Khalil (2024) and Gelan (2025), which identify unmanaged waste and visual clutter as signs of fragmented planning and weak regulatory frameworks. Additional research also links billboard proliferation and litter to psychological stress and diminished quality of life, particularly for vulnerable groups, such as low-income communities, the elderly and people with disabilities (Gelan 2025). While such impacts are often studied in urban contexts, their relevance to natural and peri-urban protected areas is increasingly evident. Additionally, Turton (2005), in his study of tourism-related environmental impacts in the Wet Tropics of Queensland World Heritage Area, emphasised the importance of tailoring waste governance and signage regulation to the ecological characteristics of each zone. The current study builds on this perspective by demonstrating that even low-density tourism areas — typically assumed to be less affected — are vulnerable to visual degradation when management resources and priorities are unevenly distributed. To mitigate these impacts, protected area governance should incorporate clearly designated signage zones, adaptive and zone-specific waste management systems and regulatory frameworks that reflect both tourism intensity and ecological sensitivity.

Graffiti and the informal use of public spaces were most frequently observed in zones with high or transitional levels of tourism development. These visual disturbances are likely driven by a combination of factors, including overcrowding, a lack of designated recreational areas and insufficient surveillance or site management. These findings align with Bulcão et al. (2004), who highlight the influence of inadequate management on visual degradation in cities. While often perceived as minor infractions, such disturbances reflect broader governance challenges, particularly the lack of participatory planning and sustained community involvement. Saghir (2019) similarly identified graffiti as a recurring form of visual impact in urban and suburban landscapes and emphasised its association with weak governance and disengaged stakeholders. Case studies from Kinabalu National Park in Malaysia and Khao Yai National Park in Thailand further demonstrate that strong local participation in site planning and enforcement contributes to improved landscape stewardship and reduced visual impacts (Goh and Yusoff 2010; DNP 2024). In contrast, this study reveals that, in Mu Ko Chang's highly developed zones, limited stakeholder engagement has led to unregulated use of public spaces, aesthetic decline and deterioration of site quality. Addressing these challenges will require targeted investment in civic engagement, clearer spatial planning and community-based stewardship programmes that promote shared responsibility and pro-conservation behaviour amongst both residents and visitors.

The presence of abandoned infrastructure in low-tourism areas of Mu Ko Chang National Park reflects broader post-pandemic trends observed across protected areas in Southeast Asia. These structures, often the result of incomplete or poorly-planned tourism developments, have become persistent visual blights, disrupting the Park's natural scenery and diminishing both visitor ex-

perience and ecological integrity. Visually, they create a sense of neglect; ecologically, they contribute to habitat fragmentation and landscape degradation. Such abandoned structures also highlight governance shortcomings, particularly where recovery efforts lack strategic coordination and long-term planning (Goh and Yusoff 2010; Bhammar et al. 2021). These findings align with Bhammar et al. (2021), who describe abandoned infrastructure in post-COVID tourism landscapes as markers of stalled investment and inadequate crisis response. Similarly, Elleithi et al. (2022) reported that deteriorating structures in Batna, Algeria, represent ongoing urban challenges with global significance. In Mu Ko Chang, the persistence of such developments underscores the urgent need for strategic rehabilitation, land-use reassessment and the integration of visual quality criteria into recovery and spatial planning. Furthermore, disparities in infrastructure maintenance across management zones suggest a tendency to prioritise high-tourism or revenue-generating areas, leaving low-traffic zones vulnerable to neglect and long-term visual decline.

In Mu Ko Chang National Park, poorly maintained public utilities, such as rusted signposts, damaged pathways and neglected facilities, were most frequently observed in low-density tourism zones. Although less visually prominent than litter or billboards, these forms of degradation significantly affect visitor perception, safety and the overall quality of the protected area experience. This pattern is consistent with findings by Nawaz and Wakil (2022), who examined visual pollution in urban areas of Pakistan and found that maintenance disparities often stem from economic considerations rather than environmental priorities. In the context of protected areas, such inequities reflect a multiple-standard management approach, where high-tourism zones receive preferential attention, while less-visited areas are overlooked. From a sustainability perspective, this imbalance undermines the ecological and functional integrity of the entire landscape. These findings highlight the need to establish baseline infrastructure maintenance standards across all zones, regardless of tourist volume, to promote consistent service delivery, aesthetic coherence, and long-term resilience in conservation planning.

The findings of this study confirm that, without integrated land-use planning that bridges conservation priorities and development pressures, visual pollution can serve as a persistent indicator of policy failure, undermining both ecological resilience and public trust in protected area management. Effectively addressing these challenges requires governance models that balance visitor services with visual harmony and ecological function, as emphasised in international frameworks, such as the IUCN Green List and the GSTC destination criteria. Overall, the study demonstrates that visual pollution is not merely an aesthetic issue, but a multidimensional conservation concern, deeply intertwined with governance, infrastructure design, spatial planning and community participation. A degraded visual environment can diminish the perceived value of protected areas, discourage pro-environmental behaviour and reduce public support for long-term conservation goals. Moreover, visually disruptive elements often signal broader ecological stress, including habitat fragmentation, waste mismanagement and unregulated development. While earlier studies have primarily approached visual pollution as a matter of perception, this research contributes to the growing recognition of its structural and spatial implications for protected landscapes. Mitigating visual degradation requires

more than short-term aesthetic solutions. It calls for institutional reform, inclusive planning processes and zoning strategies guided by ecological and cultural values. Understanding and managing visual pollution, therefore, is essential not only for enhancing visitor experience, but also for sustaining the ecological integrity and social relevance of protected areas.

Management recommendations for protected area zoning and visual integrity

The findings of this study underscore the importance of adopting zone-specific management strategies that respond to the varying pressures, ecological sensitivities and stages of development within Mu Ko Chang National Park. A differentiated approach is essential to ensure that landscape management supports both conservation objectives and sustainable tourism. Based on the study results, the following zone-based management recommendations are proposed:

- High-density tourism zones should implement stricter enforcement of visual impact regulations, including standardised signage design and location restrictions. Improving waste management systems, expanding anti-graffiti initiatives and improving public utilities will help accommodate high visitor volumes, while minimising aesthetic degradation.
- Medium-density areas require clear zoning of public spaces and proactive development controls to prevent fragmented infrastructure expansion and emerging visual clutter. These transitional zones would benefit from integrated land-use plans that guide future development and tourism growth while preserving scenic integrity.
- Low-density zones should focus on landscape-scale planning and regular maintenance, particularly the rehabilitation or removal of abandoned infrastructure. Enforcing signage regulations and preventing unmanaged visual encroachment are also critical, as these areas serve as both ecological buffers and protected scenic zones.
- Community zones would benefit from the co-development of aesthetic guidelines and visual stewardship tools in collaboration with local stakeholders. Integrating local knowledge ensures that livelihood activities, such as tourism services, signage and small-scale businesses, remain visually harmonious with the surrounding landscape and cultural context.

In addition to zone-specific actions, system-wide management strategies are essential to enhance overall governance and visual quality across the Park. These include: (1) establishing community-based waste management systems that foster shared responsibility; (2) developing ecologically informed visual landscape guidelines to support infrastructure planning; and (3) designating and regulating advertising zones to minimise visual pollution near sensitive viewpoints and ecologically important areas. Finally, holistic collaboration amongst all stakeholders, such as park authorities, local governments, tourism operators and utility providers, is critical for managing infrastructure development in line with conservation priorities. Visual pollution should not be treated solely as an aesthetic issue, but rather as a multidimensional conservation concern that reflects broader challenges in land-use governance, community

participation and sustainable tourism planning. Addressing it effectively is essential for maintaining both the scenic and ecological integrity of protected landscapes amid growing tourism pressure.

Recommendations for future research

Future research should investigate how different stakeholder groups, particularly visitors, local communities and park managers, perceive visual pollution in protected areas. For visitors, studies could examine how perceptions of visual disturbances influence satisfaction, place attachment and pro-environmental behaviour. These insights are critical for enhancing the visitor experience while supporting conservation goals. For local communities, research on community-based visual stewardship models is needed to understand how residents can actively participate in monitoring and managing visual quality. This would help integrate local knowledge and cultural values into aesthetic management. Additionally, from a management perspective, future studies should explore what incentives, co-management arrangements or institutional structures best support community-led aesthetic regulation. Collectively, these research directions can help bridge ecological objectives with social expectations, leading to more inclusive and sustainable landscape management in protected areas.

Conclusions

This study presents a systematic, landscape-based assessment of visual pollution in Mu Ko Chang National Park, identifying eight key types of visual disturbances: billboards, graffiti, garbage dumps, abandoned buildings, wastewater discharge points, improper use of public spaces, electric poles and wires and poorly maintained public utilities. The impacts of these disturbances were compared across four distinct zones, including community areas, high-, medium- and low-density tourism zones. The results demonstrated that electric poles and tangled overhead wiring emerged as the most frequent types of visual degradation, contributing significantly to scenic fragmentation across all zones. Other disturbances, such as unmanaged waste, excessive signage and graffiti, were particularly concentrated in high-use tourism zones or areas lacking regulatory management. ANOVA results confirmed statistically significant differences in visual pollution across zones, reinforcing the need for spatially responsive management. High-density zones were heavily impacted by waste and graffiti, reflecting tourism-related pressures and inadequate maintenance. Medium-density zones showed conflicts over informal public space use and transitional development. In contrast, low-density zones exhibited elevated visual degradation from abandoned infrastructure and signage, pointing to governance and planning gaps. In community zones, visual impacts were influenced by both structural conditions and behavioural factors, highlighting the importance of engaging local stakeholders in visual stewardship efforts.

These findings demonstrate that visual pollution in protected areas is not merely an aesthetic concern. It also serves as an indicator of broader governance, land-use and conservation challenges. Academically, this study contributes to the growing literature by framing visual pollution as a spatially

differentiated, multi-dimensional issue and by introducing a methodological approach for assessing visual quality within protected landscapes. For protected area managers and policy-makers, the results demonstrate the urgent need for zone-specific strategies that integrate sustainable infrastructure design, targeted regulation, community-based monitoring and inclusive visual planning. Improving visual quality is essential not only for maintaining ecological integrity and scenic values, but also for enhancing visitor satisfaction, promoting pro-conservation behaviour and fostering long-term public support for protected area management. This research offers practical insights for bridging the gap between conservation science and landscape management, reinforcing visual quality as a critical element in sustainable tourism and nature conservation.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

Use of AI

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Author contributions

Conceptualisation: SP, KA, TK and KS. Methodology: SP, KA and TK. Software: SP and KA. Data curation: KA, SP and KS. Data validation: SP and KA. Formal analysis: SP, KA and TK. Investigation: SP, KA, TK and KS. Resources: SP and KA. Writing – original draft: SP and KA. Writing – review and editing: SP, KA, TK and KS. Visualisation: SP and KA. Project administration: KA. Supervision: SP. All authors have read and agreed to the published version of the manuscript.

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Data availability

All of the data that support the findings of this study are available in the main text.

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